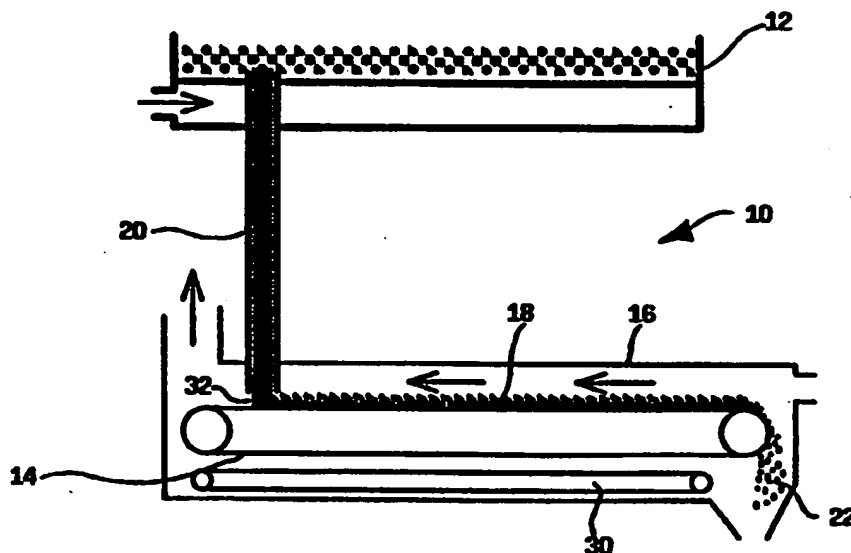




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(54) Title: CONVEYOR/COOLER OF LOOSE MATERIALS



## (57) Abstract

A conveyor/cooler (10) of hot loose solid materials produced by fluid bed boilers (12) and various industrial processes fundamentally comprising one or more feeding channels, substantially vertical or at any inclination wherein, because of gravity, said material (18) leaves the combustion chamber of the boiler, and a sealed metallic container means (16) connected to the downstream end of said discharging channel(s) (20) is disclosed. Within said container a metallic conveyor belt means (14) driven by proper motor means is placed on such a conveyor belt means, the material from the downstream end of the channel(s) is laid, thus forming a travelling continuous bed, said belt means thus constituting a regenerative heat exchanger which absorbs heat from material during the forward run and gives it back to air during the backward run.

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## "CONVEYOR/COOLER OF LOOSE MATERIALS"

5           The present invention relates to a conveyor/cooler of loose solid materials with small particle size, such as bottom ash produced by fluid bed boilers or casting sand, sintered power, cement clinker, slag or small particle size minerals produced during various industrial processes of burning, cooking, sintering etc. While the present invention is applicable to treating various hot solid loose material, such as the above  
10 listed, a preferred use thereof is to treat ash produced in fluid bed boilers which will be referred to in the following as an exemplificative and not limiting embodiment.

          In fluid bed burners, the more used system for extraction and cooling of ashes (which exit from the combustion chamber at temperatures around 800-900°C) is constituted by a water cooled scroll (the water cools both the external shell and the  
15 scroll). But such a system has the following drawbacks:

- high wear because of the erosion action exerted by the ash (which has a high content of silica and other abrasive materials) on the metallic parts both of the scroll screw and the shell;

- danger, because of the fast wear of the shell, of creation of slits which,  
20 causing the water to contact high temperature ashes, could cause a danger of explosions because of the fast evaporation of water;

- possibility of sudden stops of the scroll in case there are hard materials having sizes higher than the distance between the scroll screw and the enclosing shell; and

- dispersion into the environment of the whole heat content which cannot be  
25 recovered.

In addition to the above, there exist the problem of a high consumption of water for carrying out cooling, water nowadays has a very high value and must be safeguarded from any kind of pollution.

The above mentioned problems and shortcomings are overcome by the conveyor/cooler according to the present invention having the features set forth in the characterizing part of claim 1. Further advantageous features of said apparatus are set forth in the dependent claims.

The characteristics, objects and advantages of the invention will be more evident by the following disclosure and the annexed drawing relating to non limiting embodiments wherein the various figures:

- Fig. 1 is a diagrammatic view of a known apparatus of the prior art for conveying loose materials, with a water cooled scroll;
- Fig. 2 is a diagrammatic view of an apparatus according to the present invention for conveying/cooling loose materials such as ash from fluid bed boilers;
- Fig. 3 and 3a are side and front diagrammatic views, respectively, of one embodiment of the device for distributing material on the belt according to the present invention;
- Fig. 3b and 3c are side and front diagrammatic views, respectively, of a second embodiment of the device for distributing material on the belt according to the present invention;
- Fig. 4 is a diagrammatic cross section of the metallic belt conveyor/cooler according to the present invention;
- Fig. 5 shows a diagrammatic view of the device for adjusting the extraction speed;
- Fig. 6 shows a diagrammatic view of the device embodiment which operates

under vacuum with respect to environment and provides energy recovery into the boiler;

- Fig. 7 is a view similar to Fig. 6 and represents a diagrammatic view of the vacuum device not provided with energy recovery into the boiler;

5        - Fig. 8 is a schematic view of the device in its embodiment under pressure;

- Fig. 9 is a diagrammatic view of the sealing lateral chamber into conveyor/cooler according to the present invention, used in the embodiment under pressure;

10       - Fig. 10 is a frontal diagrammatic view of the mixing devices in the form of cooling plowshares according to the present invention; and

- Fig. 11 is a side view thereof;

- Fig. 12, 12a, 13 and 13a show lateral and front views respectively, of a transition member connected to the device adapted to make the thickness uniform; and

- Fig. 14 is a diagrammatic view of proper spoon mixers.

15       Obviously, the same reference numbers through the various figures indicate the same or equivalent parts. We would like to point out again that while the present invention is applicable to treating various hot solid loose material, a preferred use thereof is to treat ashes produced in fluid bed boilers which will be referred to in the following as an exemplificative and not limiting embodiment.

20       Figure 1 is a diagrammatic view of a prior art apparatus for conveying loose materials, having a water cooled scroll which has the above disclosed shortcomings. Briefly, for clarity of disclosure, reference number 100 is for the boiler, the ash of which are conveyed by scroll 102 which has an ash exit 104 to the processing system. Further, the cooling water circulating path 106 is also diagrammatically shown.

25       The conveyor/cooler 10 according to the present invention uses, for conveying

and cooling of loose materials, such as particularly ashes and other combustion matter from fluid bed boilers 12, a metallic conveyor belt means 14, preferably made of steel, properly inserted into a sealed metallic container 16 (see Figure 2) and driven by proper motor means.

5           Ash 18 leaves the combustion chamber of boiler 12 by gravity through one or more vertical discharge channels 20 also used as pressure separation means. The amount of material to be extracted is adjusted according to a pressure signal or an overpressure signal generated at a proper height in the container bottom area where the discharge tubes dip and which contains material to be discharged. Below such  
10       channels or tubes 20, at a distance such that passage of pieces of materials 18 having the largest available size (but less than  $1/3$  of the tube diameter, as its minimum size), the metallic conveyor belt 14, on which the material is laid forming a continuous bed which is moving toward the exit area 22 is provided.

          Cooling of material 18 is mainly carried out by means of air flowing against the  
15       stream with respect to material itself; said air could be both forced from outside to metallic container 16 inside through a proper ventilation means (and in such a case the cooler operates at a positive pressure with respect to outside) or drawn inside container naturally by generating in it a natural depression. Choosing both the under  
20       pressure operation or the depression operation will be dependent on the convenience of interfacing in the more proper manner conveyor/cooler 10 to the process from which the hot material to be cooled comes, as will be clear from the following disclosure. Conveyor/cooler 10 can operate according to two different modes, with them being dependent on needs of cooling and conveyor/cooler 10 length which, in particular cases, could also be a conveyor of material itself.

25           While the apparatus is operating under pressure (diagrammatically shown in

Fig. 2 too) the heat exchange is carried out naturally, without material mixing means for augmenting heat exchange between hot material and cooling air. In such a mode it will be convenient to distribute material on belt itself in a uniform manner and in thin layers to the end of augmenting the exchange surface; material will transfer heat upwardly by radiation (to the top of metallic container, which in turn, by convection, will transfer heat to both internal and internal air, material will also transfer heat downwardly to the belt itself by contact; belt 14 could transfer heat to air which is inside the cooler both during forward (by means of its down side) and backward (by means of both sides).

To the end of distributing material in an even manner, downstream the discharge area a proper material distributing means D is provided, said means could be, according to particular cases constituted by an adjustable high blade L (to the end of providing adjustment of material 18 on belt 14) shown in Fig. 3 and 3a or a proper set of hammer M hinged to a bar the height thereof is adjustable, shown in Figures 3b and 3c, also for obtaining the desired material height. The first assembly is used in case the layer height is larger than the provided maximum dimension of material pieces to be cooled; the second one is applicable where said dimension could be higher than the desired material 18 layer thickness.

Feeding channels 20 are preferably provided with a safety mechanic control device (not shown) (such as blade valves) and sensor means (not shown) which control the material level 18. The level has to be such as to provide separation between the combustion chamber environment (in the down part thereof, as it is known, there exist a pressure which is around that of one meter of water column) and the pressure of metallic container 16 of said conveying/extractor belt 14 (which operates at a different pressure).

In Fig. 2, as well as in Figure 4-9, a chain system means 30 provided with scrapers 30 is also shown, said scrapers rubbing against the container 16 bottom for conveying toward the exit the powdery material which is dropped from belt 14 and has deposited onto the bottom.

5 At the bottom end of the discharging channels, a special transition valve assembly 24 provides for the following functions:

- it prevents the ash discharge tubes 20 to become empty in case material 18 is extremely fluid;

- it distributes ash 18 along the whole length of belt 14 in a thin layer so that the heat exchange surface is enhanced, both for radiation (both toward the top and bottom) and convection (toward the top) and conduction (toward the bottom because of the contact with the metallic belt 14); and

- it allows passage of pieces of excessive size.

15 The gap which provides material passage under the bottom edge of the transition valve or device could be adjustable to the end of obtaining a proper thickness on belt. Transition valve will be connected to the belt metallic container and connection to the part of discharge tube integral to combustion chamber will be carried out by a proper joint which allows expansions caused by the high temperatures.

20 To the end of avoiding the corrosive action caused by high temperature material contacting parts subjected to friction, a proper coating of a ceramic material could be placed on them with said coating having a proper thickness and proper characteristics. Also, to the end both of reducing metallic part temperature and thermal recovery, thermal recovery fins could be fixed to the upper part of transition valve. Said finning  
25 could also be fixed to a wide or narrow area of discharge tube(s).

In the upper part of tube 20 a sensor (not shown) is provided, said sensor being adapted to detect possible material low level, which sensor drives a proper valve to close when no material is detected. In such a way, the necessary separation between the boiler combustion chamber 12 and conveyor/cooler 10 is provided, even during irregular operating conditions.

To the end of withstanding the abrasion exerted by the hot ash on the metallic parts subjected to rubbing, a coating of ceramic material or any other proper anti-wearing material of a proper thickness is preferably added at the bottom end of the feeding channel(s). A cross section of the belt conveyor/cooler is shown in Figure 4.

The thickness of the material 18 layer on belt 14 is adjusted with respect to the particle size of the ash and to the cooling needs. As the thickness is set, the ash capacity is adjusted by changing the moving speed of belt 14 in accordance with a signal from an overpressure sensor placed at a proper height in the bottom area of the fluid bed (as to maintain the operating parameters of the fluid bed, namely pressure or overpressure, at the proper value) (see Fig. 5). Such an adjustment could be carried out automatically by an adjusting loop constituting of a transmitter 34 of the variable to be controlled (pressure or overpressure of the bottom area of the fluid bed), a controller 36 for delivering the exit signal and a frequency converter 38, which regulates revolutions of belt driving motor in accordance with the received signal.

Belt 14 is, as above mentioned, enclosed into a sealed container 16; as above mentioned it can operate, according to the interface criterions between the extraction system and the boiler, both under vacuum with respect to the atmosphere or under pressure.

In one case, two kinds of interfaces with the combustion chamber are available,

depending on whether or not it is convenient to use the heat recovery possible with the extraction system.

To the end of using the possibility of heat recovery which is allowed by the system, the assembly of Fig. 6 is provided.

5 In such a case, the external air, drawn in the desired amount (the air amount entering the extractor depends on the size of the air intake or it is adjustable by installing proper variable feeding valves) by the vacuum at which the belt 14 container 16 operates, absorbs heat delivered by the ash because of the contact between air and the ash itself, with container 16 walls which are heated by radiation, with the metallic  
10 belt 14, both during its forward and backward runs (we have to take into consideration that in this specific case, the belt operates as a regenerative heat exchanger because it absorbs heat from ashes during the forward run and it delivers such a heat to the air during the backward run) and generally with all the metallic surfaces impinged by air during its travel.

15 The so heated air can be fed back into combustion chamber of boiler 12, thus joining it to the primary or secondary combustion air (preferably to secondary air because of the low pressure at which is introduced into combustion chamber), this could happen through an additional fan 42 of primary or secondary air 44 and 46, respectively, which allows to bring the air exiting from extractor container to the  
20 requested pressure.

In case it is not believed necessary to reuse the recovered heat energy (see Fig. 7), it is also possible to discharge air into atmosphere after proper filtering by a filter means 48, by using the chimney C effect which is caused by hot air or an ejection fan (not shown) according to particular cases and operating conditions.

25 The vacuum operation of the system eliminates any problem concerned with the

exit of powders and gases and allows to inspect the extractor 10 also during operation without any inconvenience. It will be sufficient to size in the proper manner openings providing air feeding. They could have a fixed area or a variable area, if a cooling area control is required.

5        On the other hand, it makes the reuse of heat recovery more complicated due to the need of a further machine (fan 42) which must operate in hard working conditions (high temperature and powders).

      The operation under pressure eliminates these shortcomings because it uses, for cooling ashes, air taken from delivery of one of the primary or secondary air fans  
10        (primary air fan 46 in Fig. 8) which, before being fed into boiler, travels through the ash extractor or indeed its metallic container 16 (see Fig. 8).

      This arrangement, on one hand makes easier the interfacing with boiler, on the other hand requires special measures for preventing exiting of powders, both for environmental problems and for powder infiltration in the seals placed between  
15        containing wall and rollers or guide and transmission drums.

      A solution for this problem is to arrange all the powdery air exiting sites within a chamber 50 maintained under a pressure lightly higher than the inner pressure, said chamber could have one or more external transparent walls, of properly stiffened glass, for example for providing visual inspection of the roller operation (see Fig. 9).

20        According to the operating conditions (where, for example it is necessary to discharge ashes at low temperature, or high ash capacity, or when there is the possibility to have a proper extractor length suitable for the cooling requirements) it could be necessary to increase the heat exchange between ashes and air beyond the value allowed by the illustrated system while a forced drive of solid material on belt  
25        is not used.

This can be made in various ways:

- each of the feeding channels from combustion chamber to the belt can be constituted by two concentric tubes (not shown but evident for a man skilled in the art), externally finned, if necessary. In such a case, air coming from extractor flows  
5 through the annular gap existing between the two tubes, increasing the ash cooling and the heat energy recovery as well as the personnel safety;

- insertion of proper metallic surfaces (not shown) with a high or low number of fins according to the need, between belt and container roof which, by absorbing the ash radiated heat, increase the air exchange surface. Said surfaces also constituting an  
10 optical shield between ashes and the external upper wall of container, will allow to maintain the carter external surface at an acceptable value;

- spraying of pulverized water on the bottom part of belt during the forward  
travel or on the upper part during backward travel, for the purpose of lowering the temperature of the belt itself. In such a manner, the cooled belt is able to remove a  
15 higher amount of heat from ashes (the metallic belt conveys heat to water which suddenly evaporates through very fine drops). It is likely that, because of the ash temperature of about 800°C, temperature rates on belt plates of about 300-350°C are generated while, by inserting proper sprayers, said heat rate could be lowered to about  
150-200°C. A plate temperature sensor could meter the proper amount of water so  
20 that condensate development can be avoided.

Where the measures used for the purpose of increasing cooling of solid material are not enough, material mixing means could be used in order to

- mixing material on the belt in order to make its temperature uniform; and
- increasing the contact surface between hot solid material and cool air.

25 These means could be:

- spoon mixers (c) mounted on axes normal to the belt 14 direction, which mixers are driven by material itself (see Fig. 14); said mixers c, installed along one or more lines and staggered, in order to act on the whole material provide for moving material upwardly and dropping it back on bed, exposing a main part of solid particle to the cooling action of air. Where required, said spoon mixers could be driven by a proper motor instead of material itself

- insertion of plowshares 54, fixed in such a manner that solid material laid on belt can be mixed (see Figures 10 and 11). It is known that ashes have low heat conductivity characteristics, whereby their mixing could obtain a uniform temperature of solid particles in an effective manner. Such devices could be especially useful when, because of particular reasons (for example high material capacity) is necessary to have not enough low material layers. Moreover said plowshares 54 can include inner channels 56 for conducting air which could be blown into the solid material 18, also for the purpose of increasing the heat exchange with the cooling air. Each single inner channel 56 will be connected to a main air feeding channel 58. To the end of reducing erosion, a coating of ceramic material could be carried out on the external plowshare surface. Said plowshares are connected in an oscillating manner and they are free to rotate around the main channel 58 which further acts as a supporting shaft so that any erratic matter can pass therethrough. A proper counterweight or elastic counteracting system move back plowshares into operating position. According to the heat exchange needed for obtaining the desired temperature value, one or more lines of staggered plowshares 54 can be added.

Clearly, when one believes necessary to use said mixing means, the material layer, unlike what indicated for the first kind of use of the cooling belt, will be sufficiently thick in order to allow a good dip of said means into the solid material.

The first mixers (spoon mixers) will be generally used for fine materials which cannot cause blocking of spoons; the second mixers (plowshares) could be used when such a blocking is possible. Indeed in this case the plowshares may rise rotating around the rod to which they are pivoted.

5        In a preferred embodiment the discharge tubes will be finned in such a manner as to provide an effective cooling and higher heat recovery which is particularly convenient in such an embodiment.

10        In addition to solve all the prior art shortcomings, the present invention has the further advantage that when the material exits from conveyor/cooler, said material is completely dried. This is an important feature in processes such as waste burning wherein ashes must be subjected to further treatments such as sintering or vitrification, in other words they are a secondary product. Ash drying treatments of conventional apparatus are here avoided.

15        It is apparent that modifications, changes, adaptations and substitutions of parts can be made in the embodiments disclosed as illustrative and not limitative without departure from the scope of protection defined by the following claims.

## CLAIMS

1. Conveyor/cooler (10) of hot loose solid materials produced by fluid bed  
boilers or various industrial processes comprising one or more discharge channels  
fundamentally vertical or at any inclination along which, because of gravity, said  
5 material (18) leaves the area wherein it is generated and a sealed metallic container  
means (16) connected to the downstream end of said discharge channel(s) (20),  
characterized in that within said container (16) a conveyor belt means (14) driven by  
proper driving means is placed and on such a belt (14) the material (18) from the  
downstream end of channel(s) (20) is layered forming a continuous travelling material  
10 (18) bed, said belt means (14) thus forming a regenerative heat exchanger which  
absorbs heat from material (18) during the forward run and it delivers it to air inside  
the cooler both during forward run, by its down side, and backward run by both its  
sides, the distance (32) between bottom or downstream end of discharge tube(s)  
(20) and belt means (14) being fundamentally such as to allow passage of pieces of  
15 material (18) having the largest supposed size.

2. Conveyor/cooler (10) according to claim 1, characterized in that said  
discharge channel(s) (20) also provide a pressure separation means in order to create  
separation between upward and downward pressure as a plug.

3. Conveyor/cooler according to claim 2, characterized in that, as the thickness  
20 of material (18) layer on belt (14) is set, said material capacity is adjusted by changing  
the advancing belt (14) speed according to a signal from a proper overpressure means  
or any other variable indicative of the amount of material to be discharged.

4. Conveyor/cooler (10) according to claim 3 characterized in that said capacity  
adjustment is automatically carried out by an adjusting loop composed of a  
25 transmitter (34) of the variable to be controlled, a controller (36) for outputting an

output signal and a frequency converter (38) adjusting number of revolutions of motor means driving the belt (14) movement.

5. Conveyor/cooler (10) according to any of the preceding claims, characterized in that it operates under vacuum with respect to atmosphere.

5        6. Conveyor/cooler (10) according to claim 5, characterized in that said conveyor/cooler (10) allows recovery of heat which is taken from material (18), said heat recovery being carried out through vacuum at which container (16) works and by introducing the so heated air in a boiler (12) chamber of combustion thus joining it to primary or secondary combustion air through an additional secondary or primary  
10       fan means (42), respectively, which allows to bring air exiting from container (16) to the requested pressure.

7. Conveyor/cooler (10) according to claim 5, characterized in that said conveyor/cooler (10) does not allow recovery of heat taken from material (18) to be cooled, the external air which has absorbed heat being discharged into atmosphere  
15       after proper filtering through a filter means (48) by using a chimney effect or by a proper expulsion fan.

8. Conveyor/cooler according to any of claims 1-4, characterized in that it operates under pressure by taking cooling air from delivery of one of fans (46, 44) of primary or secondary air, respectively, which, before entering the boiler, travels  
20       through container (16) of conveyor/cooler (10) where, by taking heat from material (18), heats itself

9. Conveyor/cooler according to claim 8, characterized in that all the possible exits of powdery air of container (16) are housed within a proper chamber (50), with said chamber being maintained at a pressure higher than inside container (16).

25       10. Conveyor/cooler according to claim 9, characterized in that one or more

inner walls (52) of said chamber (50) is/are made of a transparent material so as to allow inspection of chamber (50) from outside.

11. Conveyor/cooler (10) according to any of the preceding claims, characterized in that for the purpose of increasing heat exchange between material (18) and cooling air, proper material mixing means are provided connected in such a manner as to mixing the solid material (18), said mixing means being free of rotate around a main shaft and being plowshares (54) or spoon mixers (c).

12. Conveyor/cooler (10) according to claim 11 characterized in that each of said plowshare means (54) comprises inner channel means (56), each of said inner channel means being connected to a main air feeding channel (58) closed within and fundamentally formed by said main shaft.

13. Conveyor/cooler according to claim 11, characterized in that said spoon mixing means (c), placed along one or more lines, are driven by material (18) itself of by proper motor means.

14. Conveyor/cooler according to any of the preceding claims, characterized in that said discharging channels (20) are provided with a safety mechanical control device such as blade-valves and sensor means which control discharged material (18) level.

15. Conveyor/cooler (10) according to any of the preceding claims characterized in that a proper transition valve assembly is provided in proximity of the downstream end of each tube (20) so as to uniformly meter material (18) on belt (14), to avoid emptying of tube (20) and to allow passage of pieces having exceptional sizes, said assembly (24) comprising: a closing device (26) downstream of feeding tube(s) (20); a container housing (I) and oscillating means (P) upwardly hinged with such a height between hinge and belt surface being adjustable.

16. Conveyor/cooler according to claim 15 characterized in that said transition member comprises a blade means (L) having an adjustable height.

17. Conveyor/cooler according to claim 15, characterized in that said transition member comprises hinged hammer means (M).

5        18. Conveyor/cooler (10) according to any of the preceding claims, characterized in that scraper means (30) are provided for scraping material powders from the bottom where they settled and discharging it.

19. Conveyor/cooler (10) according to claim 1, characterized in that said discharge channel(s) (20) also provide a pressure separation means in order to create separation between upward and downward pressure as a plug.